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A HIGH RESOLUTION H I STUDY OF THE ISM LOCAL TO GALACTIC WOLF–RAYET STARS

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RESUMEN

Por medio de observaciones interferométricas llevadas a cabo en la radiación emitida por el átomo de H I en la linea de 21 cm , se ha analizado el medio interestelar ubicado en las cercanías de las estrellas Wolf-Rayet WR 132 y WR 140. Dichos datos muestran la presencia de dos mínimos en la distribución del H I. Los mismos son visibles en los rangos de velocidades de +13 a +21 km/s (WR 132) y de −18 a −7 km/s (WR 140), respectivamente. Estas estructuras, muy probablemente, han sido creadas por la acción mancomunada de cada estrella WR y su progenitora. Cada uno de los mínimos presenta en su interior dos mínimos relativos. La posición actual de la estrella WR no coincide con el centro geométrico de la cavidad de H I, ni con ninguno de los mínimos relativos. La estructura de doble mínimo detectada en el interior de cada cavidad, un hecho también encontrado en otras cavidades de hidrógeno neutro asociadas a estrellas WR, podría ser una consecuencia del proceso de interacción que tuvo lugar entre el viento de la estrella y el medio interestelar.

ABSTRACT

The neutral matter distribution from the interstellar medium (ISM) located in the vicinity of the Galactic Wolf-Rayet (WR) stars WR 132 and WR 140 has been examined by means of the H I 21-cm line observations obtained with high angular resolution obser vations. The most interesting discoveries are the presence of huge ovoidal H I minimum spanning the velocity range +13 to +21 km/s (WR 132) and −18 to −7 km/s (WR 140). These minima were created, very likely, by the joint action of the progenitor of both WR stars and the WR star itself. Inside each cavity, two minima are clearly discernible. The WR star is offset with respect to either the geometrical centre of the main H I void or the inner H I minima. The dual H I minimum geometry observed inside the main H I cavity, a feature also seen in the H I distribution od the ISM located close to other Galactic WR stars, may be a consequence of the interaction process itself.

Key Words: **ISM: BUBBLES — RADIO LINES: ISM — STARS: INDIVIDUAL: HD 190002, HD 193793 — STARS: WOLF-RAYET**

1. INTRODUCTION

Wolf-Rayet (WR) stars, believed descent from massive stars (van der Hutch 1992), have high mass-loss rates ($\dot{M} = 2$ to 5×10^{-5} $M_{\odot}$/yr), high wind terminal velocities (v_{∞}=1650 to 3500 km s^{-1}), and radiate enormous amounts of Lyman continuum photons ($N_{Lyc} \sim 1.7 \times 10^{48}$ s^{-1} for a WN4 star: Barlow et al. 1981). As a result of the *combined* action of copious Lyman continuum emission and high mass-loss rates, massive stars have significant impact on their environments, playing a significant role in defining its topology and evolution.

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After the pioneering work by Avedisova (1972) and Dyson & de Vries (1972), several theoretical groups have modelled the interaction of a strong stellar wind with its surrounding ISM (see Koo & McKee 1992 and references therein). These models predict the creation around the massive star of a highly evacuated cavity ($n \sim 10^{-2}$– 10^{-3} cm^{-3}) and hot (T $\sim 10^{6-7}$ K) region surrounded by an expanding outer shell. This shell may be fully ionized by the Lyman continuum stellar flux but, if the ionization front gets trap within it, its outer portions may recombine and eventually **become observable** in the line radiation emitted by atoms and/or molecules. This overall structure is usually referred to as an *interstellar bubble* (or IB for short).

Since a given IB is characterized by a quite low volume density, when observed in the $\lambda \sim$21 cm H I line radiation, its *fingerprint* should be a **cavity** in the observed H I distribution. This cavity should be visible in the velocity range centred at *a radial velocity that is characteristic of the ISM local to the WR star.*

In this paper we would like to report on $\lambda \sim$21–cm high angular resolution line observations of a $\sim 2°$ field centred at the optical position of the stars WR 132 ($\equiv$ HD 190002) and WR 140 ($\equiv$ HD 193793). The observations were carried out using the interferometer of the Dominion Radio Astrophysical Obsevatory (DRAO).

2. PARAMETERS DERIVED FROM THE H I OBSERVATIONS

In order to investigate the presence of cavities and/or shells possibly related to WR stars, the entire data cube ($T_b(l,b,v)$) of the observed brightness temperature distribution was used to construct a series of *position vs position (l,b)* maps at constant radial velocity, showing the overall H I emission distribution. Under the assumption that a WR star will inexorably alter its local ISM, the main results of our study are the following:

a) The presence of a large ovoid H I minimum close to the optical position of each of the stars was detected. This minimum spans the velocity range $+11 \leq V \leq +23$ kms^{-1} towards WR 132, and $-7 \leq V \leq -18$ kms^{-1} towards WR 140, respectively;

b) inside the main H I cavity, two minima are clearly apparent. A similar structure has already been noticed for the IB related to WR 3 (Arnal & Roger, 1997) and WR 6 (Arnal & Cappa, 1996);

c) the location of both stars is offset from both the symmwetry centre of the main H I cavity and the central position of the inner H I minima;

d) likewise the cases of WR 3 and WR 6, no early type stars other than WR 132 and WR 140 (and its progenitors!) seems to have played a role in creating the observed H I distribution. Thus, the doble-lobe minimum feature structure observed inside the main cavity may be a characteristic intrinsic to the interaction process between the stellar wind of a massive star and its local ISM;

e) the shape and main features observed inside the H I depression cannot be explained with the standard hydrodynamic IB theory, even by relaxing the assumptions of isotropic stellar wind and homogeneous ISM.

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